

## **Appendix A. Supplementary data for *Scientific Reports***

### **H/C Atomic Ratio as a Smart Linkage between Pyrolytic Temperatures, Aromatic Clusters and Sorption Properties of Biochars Derived from Diverse Precursory Materials**

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Supporting Information consists of 23 pages, including this one.

There are 5 Tables and 2 Figures.

**Table S-1** The data of pyrolysis temperature and H/C atomic ratio from various precursor substances. The left side shows the results from our group, and the right side from others.

precursor substances	pyrolysis temperature (° C)	H/C atomic ratio	precursor substances	pyrolysis temperature (° C)	H/C atomic ratio
<b>shaddock peel<sup>a</sup></b>	700	0.16	rice husk <sup>1 b</sup> pinewood <sup>2</sup> (2h)	500 700	0.63 0.10
<b>chicken manure</b>	100	1.75	poplar wood <sup>3</sup> (10h) spruce wood <sup>3</sup> (10h) wheat straw <sup>3</sup> (5h)	400 460 525 400 460 525 400 460 525	0.79 0.60 0.41 1.04 0.50 0.47 0.74 0.52 0.46
	150	1.64			
	200	1.37			
	250	1.12			
	300	0.90			
	400	0.60			
	450	0.49			
	550	0.32			
	600	0.29			
<b>bagasse</b>	100	1.70	feed lot <sup>4</sup> (2h) poultry litter <sup>4</sup> (2h) swine solid <sup>4</sup> (2h) turkey litter <sup>4</sup> (2h)	350 700 350 700 350 700 350	0.91 0.21 0.89 0.52 1.14 0.20 0.88
	200	1.21			
	300	0.70			
	400	0.51			
	500	0.39			
	600	0.38			
	700	0.23			
<b>rice straw</b>	25	1.64	cotton seed hull <sup>5</sup> (4h) <sup>c</sup>	25 200 350 500 650 800	1.50 1.38 0.70 0.39 0.17 0.08
	150	1.56			
	250	1.11			
	350	0.72			
	500	0.36			
	700	0.14			
<b>bamboo wood</b>	100	1.54	broiler litter <sup>6</sup> (1h) saw dust <sup>7</sup>	350 700 450 550	1.05 0.37 0.58 0.14
	200	1.31			
	300	0.70			
	400	0.52			

	500	0.39	chicken litter <sup>8</sup> (2h)	620	0.35
	600	0.26	swine solid <sup>8</sup> (2h)	620	0.45
	700	0.20	corn stover <sup>9</sup>	450	0.51
<b>pine needle<sup>10</sup></b>	100	1.44	fescue grass <sup>11</sup> (1h)	100	1.59
	200	1.19		200	1.64
	250	1.08		300	1.42
	300	0.75		400	0.80
	400	0.45		500	0.52
	500	0.33		600	0.40
	600	0.26		700	0.21
	700	0.18	pine wood shaving <sup>11</sup> (1h)	100	1.81
<b>rice straw<sup>12</sup></b>	100	1.72		200	1.81
	200	1.30		300	1.34
	300	0.76		400	0.73
	400	0.58		500	0.48
	500	0.49		600	0.33
	600	0.36		700	0.20
	700	0.32	poultry manure <sup>13</sup>	300	0.89
	100	1.72		400	0.74
	200	1.30		500	0.44
	300	0.76		600	0.33
	400	0.58		700	0.32
	500	0.49	buffalo weed <sup>13</sup>	300	0.65
	600	0.36		700	0.15
	700	0.32	sewage sludge <sup>13</sup>	300	1.21
	100	1.72		400	0.87
	200	1.30		500	0.64
	300	0.76		600	0.40
	400	0.58		700	0.31
	500	0.49	paper sludge <sup>13</sup>	105	1.48
	600	0.36		300	0.74
	700	0.32		700	0.14
	100	1.72	pine needles <sup>13</sup>	300	0.62
	200	1.30		500	0.27

			700	0.08	
<b>orange peel<sup>14</sup></b>	150	1.46	rapeseed plant <sup>15</sup> (0.5h)	400	0.66
	200	1.14		500	0.42
	250	0.94		600	0.28
	300	0.78		700	0.18
	350	0.68		800	0.11
	400	0.58		900	0.06
	500	0.38	tire rubber <sup>16</sup> (2h)	200	1.02
	600	0.30		400	0.55
	700	0.29		600	0.25
				800	0.12
<b>pine wood<sup>17</sup></b>	150	1.51	peanut shell <sup>18</sup> (3h)	300	0.68
	250	0.90		700	0.25
	350	0.47	soybean stover <sup>18</sup> (3h)	300	0.75
	500	0.38		700	0.19
	700	0.14	oak bark <sup>19</sup>	450	0.44
<b>fir wood chip<sup>20</sup></b>	200	1.44	cellulose <sup>21</sup> (8h)	25	1.92
	300	0.69		250	0.47
	400	0.52		320	0.51
	500	0.37		400	0.50
	600	0.25	chitin <sup>21</sup> (8h)	25	1.84
	700	0.14		250	0.58
				320	0.56
				400	0.49
<b>rice bran<sup>22</sup></b>	100	1.71	corn cob <sup>23</sup>	500	0.47
	300	0.75	corn stover <sup>23</sup>	500	0.60
	700	0.20			

<sup>a</sup>: The biochars in the left side were all prepared by the heating rate of 5 °C min<sup>-1</sup> and a holding time of 6h.

<sup>b</sup>: The biochars in the right side were prepared by different preparing method. The holding time period was provided in the brackets behind the precursors. The precursors with no preparing parameter (such as holding period) mentioned were not followed by bracket.

**Table S-2** The sorption parameters of naphthalene onto a series of biochars (including 13 biomass data)

precursor substances	preparing methods	heating temperature (°C)	C (wt.%)	H (wt.%)	O (wt.%)	N (wt.%)	ash (wt.%)	H/C	N	$\log K_f^a$	$\log Q_e^b (C_e=0.01C_s)$	$\log Q_e^b (C_e=0.1C_s)$	$\log Q_A^c$
pine needle <sup>10</sup>	5 °C min <sup>-1</sup> <sup>d</sup> , 6h <sup>e</sup> , HCl treated	100	50.34	6.09	41.82	0.7	1.05	1.440	1.107	2.347	1.799	2.906	
		200	56.58	5.66	36.31	0.87	0.9	1.191	0.874	3.040	2.607	3.481	3.383
		250	60.48	5.47	32.36	0.85	1.24	1.077	0.777	3.217	2.833	3.610	3.677
		300	67.55	4.23	25.74	1.06	1.91	0.746	0.589	3.502	3.211	3.800	3.962
		400	76.04	2.88	18.04	1.13	2.32	0.451	0.332	4.232	4.068	4.400	4.534
		500	79.38	2.2	14.96	1.08	2.8	0.329	0.207	4.298	4.196	4.403	4.495
		600	83	1.8	11.81	0.95	2.76	0.258	0.174	4.109	4.023	4.197	4.276
		700	84.61	1.25	11.08	1.1	2.2	0.176	0.124	5.095	5.033	5.157	5.215
orange peels <sup>14</sup>	5 °C min <sup>-1</sup> , 6h, HCl treated	150	50.6	6.2	41	1.75	0.45	1.470	1.098	2.422	1.879	2.977	
		200	57.9	5.53	34.39	1.88	0.3	1.146	0.771	3.231	2.850	3.621	3.694
		250	65.1	5.12	26.51	2.22	1.05	0.944	0.815	3.485	3.081	3.896	3.916
		300	69.3	4.51	22.26	2.36	1.57	0.781	0.683	3.667	3.329	4.012	4.147
		350	73.2	4.19	18.31	2.3	2	0.687	0.537	3.779	3.513	4.050	4.215
		400	71.7	3.48	20.8	1.92	2.1	0.582	0.516	3.839	3.584	4.100	4.265
		500	71.4	2.25	20.25	1.83	4.27	0.378	0.384	3.269	3.079	3.463	
		600	77.8	1.97	14.39	1.8	4.04	0.304	0.249	3.168	3.045	3.294	
pine wood <sup>17</sup>	5 °C min <sup>-1</sup> , 6h, HCl treated	700	71.6	1.76	22.13	1.72	2.79	0.295	0.151	4.782	4.708	4.859	4.928
		150	49.2	6.2	43.6	0.26	1.04	1.512	0.947	2.723	2.254	3.201	2.768
		250	57.7	4.33	36.3	0.275	1.74	0.901	0.667	3.614	3.284	3.951	4.092
		350	65.4	2.57	29.8	0.352	2.26	0.472	0.451	4.163	3.940	4.391	4.550
		500	69.7	2.18	23.8	0.384	4.32	0.375	0.209	4.787	4.684	4.893	4.986
rice straw <sup>12</sup>	5 °C min <sup>-1</sup> , 6h, HCl treated	700	84.9	0.987	9.36	0	4.74	0.140	0.111	5.227	5.172	5.283	5.336
		300	42.09	2.66	17.06	1.19	37	0.758	0.644	4.100	3.781	4.425	4.575
cellulose <sup>21</sup>	8h	25	41.4	6.62	51.98	0	0	1.919	0.992	0.891	0.400	1.392	1.000
		250	64.9	2.52	32.58	0	0	0.466	0.256	4.516	4.389	4.645	4.756

		320	65.3	2.8	31.9	0	0	0.515	0.327	4.643	4.481	4.808	4.941
		400	77.2	3.24	19.56	0	0	0.504	0.407	4.722	4.521	4.928	5.080
chitin <sup>21</sup>	8h	25	43.8	6.72	43.03	6.45	0	1.841	1.008	0.972	0.473	1.481	
		250	55.6	2.69	30.51	11.2	0	0.581	0.426	4.088	3.877	4.303	4.459
		320	55.6	2.61	27.49	14.3	0	0.563	0.437	4.154	3.938	4.375	4.532
		400	57.1	2.33	25.47	15.1	0	0.490	0.441	4.236	4.018	4.459	4.617
		170	43.3	5.69	44.01	7	0	1.577	0.989	2.797	2.308	3.297	1.973
α-amylase <sup>24</sup>	8h	250	50	4.81	37.67	7.52	0	1.154	0.834	3.482	3.069	3.903	3.892
		350	48.7	3.93	39.85	7.52	0	0.968	0.659	3.765	3.439	4.098	4.243
		450	51.3	1.88	40.06	6.76	0	0.440	0.515	3.627	3.372	3.887	4.052
		170	43.9	6.67	42.97	6.46	0	1.823	0.846	1.293	0.874	1.720	1.687
chitin <sup>24</sup>	8h	250	47	6.18	39.63	7.19	0	1.578	0.849	2.438	2.018	2.867	2.827
		350	72.3	3.94	13.17	10.59	0	0.654	0.623	4.087	3.779	4.402	4.557
		450	67	2.98	17.8	12.22	0	0.534	0.562	3.823	3.545	4.107	4.271
		170	52.8	7.34	24.9	14.96	0	1.668	0.996	2.485	1.992	2.988	
zein <sup>24</sup>	8h	250	62.7	6.69	15.77	14.84	0	1.280	0.905	3.103	2.655	3.560	3.362
		350	61.8	4.06	21.59	12.55	0	0.788	0.685	3.622	3.283	3.968	4.102
		450	68.9	3.27	14.71	13.12	0	0.570	0.649	4.520	4.199	4.848	4.996
		300	60.81	5.62	31.06	<0.5	0.81	1.109	0.76	3.794	3.417	4.177	4.261
maple wood shavings <sup>25</sup>	25° C min <sup>-1</sup> , 2h	350	72.53	4.63	21.69	<0.5	0.61	0.766	0.77	3.973	3.592	4.362	4.436
		400	74.78	4.01	18.56	<0.5	1.66	0.643	0.66	3.727	3.401	4.061	4.205
		500	83.16	3.24	10.59	<0.5	1.79	0.468	0.21	4.248	4.144	4.354	4.447
		600	86.31	2.52	7.15	<0.5	2.2	0.350	0.21	3.810	3.706	3.916	4.009
		700	84.43	1.86	6.7	<0.5	3.37	0.264	0.35	3.055	2.882	3.232	
		300	66.79	4.92	19.25	1.88	7.15	0.884	0.73	3.242 <sup>f</sup>	2.880	3.610	3.719
maize stalk <sup>26</sup>	3h	500	72.12	3.18	14.15	--	10.56	0.529	0.89	3.377 <sup>f</sup>	2.936	3.826	3.682
		700	76.3	3.38	9.53	--	10.78	0.532	0.33	3.912 <sup>f</sup>	3.748	4.078	4.212
		200	53.71	5.42	39.57	0.88	0.42	1.211	0.95	2.705	2.235	3.185	2.726
bagasse	5 ° C min <sup>-1</sup> , 6h HCl treated	300	68.4	4.01	24.62	1.61	1.36	0.704	0.593	3.619	3.326	3.919	4.080

		400	74.12	3.15	19.86	1.27	1.6	0.510	0.317	4.040	3.883	4.200	4.330
		500	79.47	2.58	14.63	1.47	1.85	0.390	0.306	4.514	4.363	4.669	4.795
		600	79.55	2.49	14.18	1.59	2.19	0.376	0.358	4.569	4.391	4.749	4.891
		700	81.79	1.57	13.16	1.51	1.97	0.230	0.21	5.186	5.082	5.292	5.385
bamboo	$5^{\circ}\text{C min}^{-1}$ , 6h	100	47.92	6.16	44.66	0.24	1.02	1.543	0.94	<sup>f</sup> 2.235	1.770	2.710	2.329
		200	52.64	5.74	40.22	0.34	1.06	1.309	0.81	<sup>f</sup> 3.209	2.808	3.618	3.645
		300	70.72	4.15	22.39	0.62	2.12	0.704	0.59	<sup>f</sup> 3.800	3.508	4.098	4.260
		400	77.09	3.32	15.75	0.69	3.15	0.517	0.34	<sup>f</sup> 4.146	3.977	4.317	4.454
		500	83.01	2.67	10	0.63	3.69	0.386	0.21	<sup>f</sup> 4.504	4.400	4.610	4.704
		600	84.48	1.84	9.64	0.52	3.52	0.261	0.08	<sup>f</sup> 4.903	4.863	4.943	4.981
		700	86.83	1.42	8.02	0.45	3.28	0.196	0.07	<sup>f</sup> 5.237	5.202	5.272	

<sup>a</sup>: Ash corrected. The values of  $\log K_f$  are all ash corrected. The equation that is used for ash correcting is written as  $\log K_f' = \log K_f - \log (1-\eta)$ , where  $K_f'$  was the published data after unit transformation and  $\eta$  was the ash content (wt.%) in biochars.  $K_f$ ,  $K_f'$ : ( $\text{mg kg}^{-1}$ ) ( $\text{L mg}^{-1}$ )<sup>N</sup>

<sup>b</sup>: The calculated  $\log Q_e$  using the linear Freundlich equation at  $C_e = 0.01 C_s$  (or  $C_e=0.1C_s$ ), where  $C_e$  represented the equilibrium sorbate concentration in water, and  $C_s$  represented the water solubility in water of the sorbate. The linear Freundlich equation was written as:  $\log Q_e = \log K_f + N \log C_e$

<sup>c</sup>:  $\log Q_A$  represents the logarithmic maximum adsorption capacity generated from the high-concentration linear fitting of two points in the Freundlich equation at 3/4  $C_s$  and  $C_s$  equilibrium concentration.  $C_s$  refers to the naphthalene solubility in water that was  $32 \text{ mg L}^{-1}$  according to reference <sup>10</sup>.

<sup>d</sup>: The unit  $^{\circ}\text{C min}^{-1}$  refers to the heating rate.

<sup>e</sup>: The time period listed behind (such as 3h, 6h, 8h etc.) refers to the holding time.

<sup>f</sup>: Unit transformation: The  $\log K_f'$  was obtained from the equation ( $\log K_f' = \log K_f^0 + 3$ ) due to the unit transformation, where  $K_f^0$  was the published data with unit of ( $\text{mg g}^{-1}$ ) ( $\text{L mg}^{-1}$ )<sup>N</sup> in the article.

**Table S-3** The sorption parameters of phenanthrene onto a series of biochars ([including 7 biomass data](#)).

precursor substances	preparing methods	heating temperature (°C)	C (wt.%)	H (wt.%)	O (wt.%)	N (wt.%)	ash (wt.%)	H/C	N	$\log K_f^a$	$\log Q_e^b (C_e=0.01C_s)$	$\log Q_e^b (C_e=0.1C_s)$	$\log Q_A^c$
pine needle <sup>10,27</sup>	5 °C min <sup>-1</sup> <sup>d</sup> , 6h <sup>e</sup> , HCl treated	100	50.34	6.09	41.82	0.7	1.05	1.452	1.001	3.985	2.043	3.044	1.000
		300	67.55	4.23	25.74	1.06	1.91	0.751	0.605	3.780	2.607	3.212	3.375
		400	76.04	2.88	18.04	1.13	2.32	0.454	0.449	4.355	3.484	3.933	4.095
		700	84.61	1.25	11.08	1.1	2.2	0.177	0.428	5.134	4.304	4.732	4.889
rice straw <sup>12</sup>	5 °C min <sup>-1</sup> , 6h, HCl treated	300	66.84	4.22	17.06	1.88	37	0.758	0.855	5.080	3.422	4.277	4.238
rice straw <sup>28</sup>	10 °C min <sup>-1</sup> , 1h, HCl treated	450	57.9	3.31	11.8	0.83	26.2	0.686	0.43	4.152	3.318	3.748	3.906
		600	59.3	2.34	5.5	0.83	32	0.474	0.38	4.427	3.691	4.071	4.218
	10 °C min <sup>-1</sup> , 1h, HCl+HF treated	450(deash)	72.5	3.71	15.4	1.17	7.2	0.614	0.5	4.592	3.623	4.123	4.289
		600(deash)	80.4	2.53	7.4	1.14	8.6	0.378	0.4	4.779	4.003	4.403	4.556
wheat straw <sup>28</sup>	10 °C min <sup>-1</sup> , 1h, HCl treated	450	70.2	4.28	12.9	0.46	12.2	0.732	0.48	4.167	3.236	3.716	3.881
		600	77.8	3.08	5.3	0.42	13.4	0.475	0.41	4.162	3.367	3.777	3.932
	10 °C min <sup>-1</sup> , 1h, HCl+HF treated	450(deash)	74.1	3.51	15.2	0.66	6.6	0.568	0.47	4.410	3.498	3.968	4.132
		600(deash)	83.9	2.65	5.9	0.45	7.2	0.379	0.49	4.422	3.472	3.962	4.128
maize stalk <sup>28</sup>	10 °C min <sup>-1</sup> , 1h, HCl treated	450	74.4	3.81	11.8	1.01	9.1	0.615	0.43	3.971	3.138	3.568	3.726
		600	79.9	3.71	5.6	0.99	9	0.557	0.54	4.771	3.724	4.264	4.432
	10 °C min <sup>-1</sup> , 1h, HCl+HF treated	450(deash)	78.8	3.31	14	1.29	2.6	0.504	0.55	4.391	3.325	3.875	4.042
		600(deash)	84.2	2.36	6.9	1.16	5.4	0.336	0.46	4.614	3.722	4.182	4.345
chicken manures <sup>28</sup>	10 °C min <sup>-1</sup> , 1h, HCl treated	450	9.8	0.91	3.6	0.53	85.2	1.114	0.49	4.360	3.409	3.899	4.065
		600	8.7	0.5	1.5	0.33	89	0.690	0.42	4.529	3.714	4.134	4.290
	10 °C min <sup>-1</sup> , 1h, HCl+HF treated	450(deash)	26.1	2.24	15.9	1.4	54.5	1.030	0.48	4.642	3.711	4.191	4.356
		600(deash)	22.6	1.42	12	0.97	63.1	0.754	0.7	5.093	3.735	4.435	4.567
swine manures <sup>28</sup>	10 °C min <sup>-1</sup> , 1h,	450	33.7	2.55	10.2	2.57	50.9	0.908	0.48	4.289	3.358	3.838	4.003

	HCl treated	600	35.6	1.79	7.9	2.46	52.3	0.603	0.29	4.481	3.919	4.209	4.331
	10° C min <sup>-1</sup> , 1h, HCl+HF treated	450(deash)	43.4	2.77	9.9	3.53	40.4	0.766	0.54	4.915	3.868	4.408	4.575
		600(deash)	42.8	2.44	6.8	2.76	45.2	0.684	0.44	4.791	3.938	4.378	4.538
cow manures <sup>28</sup>	10° C min <sup>-1</sup> , 1h, HCl treated	450	29.5	0.95	4.1	1.39	68.1	0.386	0.55	4.546	3.480	4.030	4.197
		600	30.7	0.46	1.2	1.11	71.2	0.180	0.35	4.411	3.732	4.082	4.222
	10° C min <sup>-1</sup> , 1h, HCl+HF treated	450(deash)	51.4	2.76	14.6	2.25	28.9	0.644	0.53	4.938	3.910	4.440	4.608
		600(deash)	50.5	1.93	10	1.9	35.7	0.459	0.4	4.792	4.016	4.416	4.568
cellulose <sup>21</sup>	8h	25	41.4	6.62	51.98	0	0	1.919	1.068	2.239	0.168	1.236	1.000
		250	64.9	2.52	32.58	0	0	0.466	0.46	4.194	3.302	3.762	3.925
		320	65.3	2.8	31.9	0	0	0.515	0.508	4.778	3.793	4.301	4.468
		400	77.2	3.24	19.56	0	0	0.504	0.543	4.981	3.928	4.471	4.639
chitin <sup>21</sup>	8h	25	43.8	6.72	43.03	6.45	0	1.841	1.015	2.241	0.273	1.288	1.000
		250	55.6	2.69	30.51	11.2	0	0.581	0.515	4.570	3.571	4.086	4.254
		320	55.6	2.61	27.49	14.3	0	0.563	0.511	4.677	3.686	4.197	4.364
		400	57.1	2.33	25.47	15.1	0	0.490	0.536	4.815	3.776	4.312	4.479
a-amylase <sup>24</sup>	8h	170	43.3	5.69	44.01	7	0	1.577	1.038	3.972	1.959	2.997	1.000
		250	50	4.81	37.67	7.52	0	1.154	0.824	4.770	3.172	3.996	4.013
		350	48.7	3.93	39.85	7.52	0	0.968	0.783	4.807	3.289	4.072	4.141
		450	51.3	1.88	40.06	6.76	0	0.440	0.475	4.037	3.116	3.591	3.755
chitin <sup>24</sup>	8h	170	43.9	6.67	42.97	6.46	0	1.823	0.864	2.016	0.340	1.204	1.147
		250	47	6.18	39.63	7.19	0	1.578	0.814	3.273	1.694	2.508	2.540
		350	72.3	3.94	13.17	10.59	0	0.654	0.576	4.511	3.394	3.970	4.136
		450	67	2.98	17.8	12.22	0	0.534	0.543	4.175	3.122	3.665	3.833
zein <sup>24</sup>	8h	170	52.8	7.34	24.9	14.96	0	1.668	0.986	3.509	1.597	2.583	1.652
		250	62.7	6.69	15.77	14.84	0	1.280	0.984	4.240	2.332	3.316	2.441
		350	61.8	4.06	21.59	12.55	0	0.788	0.797	4.045	2.499	3.296	3.350
		450	68.9	3.27	14.71	13.12	0	0.570	0.564	4.158	3.064	3.628	3.795
malt spent rootlets (MSR) <sup>29</sup>	1.5h	300	53	2.8		4.5		0.634	0.55	3.230 <sup>f</sup>	2.163	2.713	2.881

MSR-MeOH <sup>29</sup>		300	55	3.4	3.6	0.742	0.51	2.910 <sup>f</sup>	1.921	2.431	2.598
MSR-NaOH <sup>29</sup>		300	59	3.9	4.8	0.793	0.43	2.892 <sup>f</sup>	2.058	2.488	2.646
cotton straw <sup>30</sup>	10° C min <sup>-1</sup> , 1h,	300	67.1	4.6	20.7	1.3	6.3	0.823	0.519	3.445 <sup>g</sup>	2.439
potato straw <sup>30</sup>	HCl treated	300	59.1	5.2	19.7	4	12.1	1.056	0.657	3.877 <sup>g</sup>	2.603
leaf <sup>30</sup>		300	62.2	5.4	16.9	4.8	10.7	1.042	0.63	3.839 <sup>g</sup>	2.617
rice straw <sup>30</sup>		300	55.3	3.7	19.5	0.8	20.6	0.803	0.513	3.669 <sup>g</sup>	2.674
wheat straw <sup>30</sup>		300	63.3	4.4	24	0.5	7.8	0.834	0.588	3.589 <sup>g</sup>	2.449
maize straw <sup>30</sup>		300	63.8	5.1	25.3	0.8	5.1	0.959	0.506	3.271 <sup>g</sup>	2.289
nut <sup>30</sup>		300	60.9	5.4	29.2	0.2	4.3	1.064	0.827	3.220 <sup>g</sup>	1.616
wood dust <sup>30</sup>		300	65.4	5.3	27.3	0	2	0.972	0.496	3.097 <sup>g</sup>	2.135
chicken manures <sup>30</sup>		300	10	0.9	4.6	0.6	83.9	1.080	0.531	4.046 <sup>g</sup>	3.016
swine manures <sup>30</sup>		300	36.5	3.6	14.9	3.2	41.8	1.184	0.519	3.672 <sup>g</sup>	2.666
cotton straw <sup>30</sup>		450	71.6	3.9	13.3	1.2	10.1	0.654	0.717	3.667 <sup>g</sup>	2.277
potato straw <sup>30</sup>		450	61.9	3.7	14.3	3.7	16.4	0.717	0.72	4.038 <sup>g</sup>	2.641
leaf <sup>30</sup>		450	63.4	3.7	12.6	5	15.2	0.700	0.778	3.866 <sup>g</sup>	2.357
rice straw <sup>30</sup>		450	57.9	3.3	11.8	0.8	26.2	0.684	0.727	3.783 <sup>g</sup>	2.373
wheat straw <sup>30</sup>		450	70.2	4.3	12.9	0.5	12.2	0.735	0.757	3.758 <sup>g</sup>	2.289
maize straw <sup>30</sup>		450	74.4	3.8	11.8	1	9.1	0.613	0.689	3.658 <sup>g</sup>	2.322
nut <sup>30</sup>		450	78.4	3.6	11.8	0.3	6	0.551	0.845	3.152 <sup>g</sup>	1.513
wood dust <sup>30</sup>		450	75.9	3.7	16.7	0.1	3.7	0.585	0.787	3.657 <sup>g</sup>	2.131
chicken manures <sup>30</sup>		450	9.8	0.9	3.6	0.5	85.2	1.102	0.897	4.211 <sup>g</sup>	2.471
swine manures <sup>30</sup>		450	33.7	2.6	10.2	2.6	50.9	0.926	0.732	3.905 <sup>g</sup>	2.485
rice straw <sup>31</sup>	1h, HCl treated	300	53.2	3.9	24.2	1.1	17.6	0.880	0.55	4.214 <sup>g</sup>	3.147
		450	57	2.6	15.6	1.2	23.6	0.547	0.45	4.137 <sup>g</sup>	3.264
		600	60.4	1.7	8.9	1.1	27.9	0.338	0.38	4.402 <sup>g</sup>	3.665
pine wood <sup>31</sup>	1h, HCl treated	300	64.7	4.8	28.6	0	1.9	0.890	0.63	3.828 <sup>g</sup>	2.607
		450	73.1	2.8	20.1	0.1	3.9	0.460	0.54	4.227 <sup>g</sup>	3.180
											3.720
											3.888

		600	81.4	2.3	11.7	0.1	4.4	0.339	0.71	5.010 <sup>g</sup>	3.633	4.343	4.469
rice straw (bleached) <sup>31</sup>	1h, HCl treated, NaClO <sub>2</sub> +CH <sub>3</sub> C OOH treated.	300	26.9	3	24.9	0.4	44.9	1.338	0.76	3.779 <sup>g</sup>	2.306	3.066	3.157
		450	39.2	2.2	27.8	0.7	30.1	0.673	0.55	4.048 <sup>g</sup>	2.981	3.531	3.699
		600	50.2	1.6	19.6	0.8	27.8	0.382	0.25	3.299 <sup>g</sup>	2.814	3.064	3.173
pine wood (bleached) <sup>31</sup>	1h, HCl treated, NaClO <sub>2</sub> +CH <sub>3</sub> C OOH treated.	300	43.1	5	45.4	0.1	6.4	1.392	0.75	3.694 <sup>g</sup>	2.239	2.989	3.089
		450	51.6	2.4	36.6	0	9.4	0.558	0.61	4.058 <sup>g</sup>	2.875	3.485	3.646
		600	65.1	2.2	25.8	0	6.8	0.406	0.89	5.052 <sup>g</sup>	3.326	4.216	4.090
cotton <sup>32</sup>	2h, HCl treated	450	71.6	3.89	13.3	1.17	10.1	0.652	0.41	4.016 <sup>g</sup>	3.221	3.631	3.785
soybean <sup>32</sup>		450	70.8	3.92	15.6	0.98	8.7	0.664	0.48	4.180 <sup>g</sup>	3.249	3.729	3.894
rice <sup>32</sup>		450	57.9	3.31	11.8	0.83	26.2	0.686	0.45	4.152 <sup>g</sup>	3.279	3.729	3.890
wood dust <sup>32</sup>		450	75.9	3.66	16.7	0.05	3.7	0.579	0.54	4.226 <sup>g</sup>	3.179	3.719	3.887
swine waste <sup>32</sup>		450	33.7	2.55	10.2	2.57	50.9	0.908	0.49	4.279 <sup>g</sup>	3.329	3.819	3.985
Dianchi lake sediment <sup>33,34</sup>	4h	0	22.04	2.42	26.04	1.52	47.98	1.318	0.978	3.834	1.937	2.915	2.173
		200	23.85	1.36	23.34	1.74	49.71	0.684	0.865	4.149	2.471	3.336	3.276
		300	21.93	1.06	20.71	1.29	55.01	0.580	0.713	4.617	3.234	3.947	4.072
		400	20.26	0.59	18.56	1.08	59.51	0.349	0.566	4.683	3.585	4.151	4.318
		500	20.43	0.4	18.23	1.07	59.87	0.235	0.325	4.277	3.646	3.971	4.104
poultry litter (hydrothermal) <sup>35</sup>	20h	250	47.46	5.72	20.7	1.25	24.9	1.446	0.91	4.724 <sup>g</sup>	2.960	3.870	3.676
swine soild (hydrothermal) <sup>35</sup>		250	40.2	3.86	22.1	1.67	32.2	1.152	0.75	4.619 <sup>g</sup>	3.164	3.914	4.014
poultry litter (thermal) <sup>35</sup>	120–420 min, HCl treated	400	53.45	3.71	15	2.8	25	0.833	0.67	4.585 <sup>g</sup>	3.286	3.956	4.101
wheat straw (thermal) <sup>35</sup>	120–420 min, HCl treated	400	65.79	3.43	20.4	0.21	10.2	0.626	0.6	3.927 <sup>g</sup>	2.763	3.363	3.526

<sup>a</sup>: ash corrected. The values of log  $K_f$  are all ash corrected. The equation that is used for ash correcting is written as  $\log K_f = \log K_f' - \log (1-\eta)$ , where  $K_f'$  was the published data after unit transformation and  $\eta$  was the ash content (wt.%) in biochars.  $K_f$ ,  $K_f'$ : (mg kg<sup>-1</sup>) (L mg<sup>-1</sup>)<sup>N</sup>

<sup>b</sup>: the calculated log  $Q_e$  using the linear Freundlich equation at  $C_e = 0.01 C_s$  (or  $C_e=0.1C_s$ ), where  $C_e$  represented the equilibrium sorbate concentration in water, and  $C_s$  represented the water solubility in water of the sorbate. The linear Freundlich equation was written as:  $\log Q_e = \log K_f + N \log C_e$

<sup>c</sup>:  $\log Q_A$  represents the logarithmic maximum adsorption capacity generated from the high-concentration linear fitting of two points in the Freundlich equation at 3/4  $C_s$  and  $C_s$  equilibrium concentration.  $C_s$  refers to the phenanthrene solubility in water that was 1.15mg L<sup>-1</sup> according to reference<sup>24</sup>.

<sup>d</sup>: The unit °C min<sup>-1</sup> refers to the heating rate.

<sup>e</sup>: The time period listed behind (such as 3h, 6h, 8h etc.) refers to the holding time.

<sup>f</sup>: Unit transformation: The  $\log K_f'$  was obtained from the equation ( $\log K_f' = \log K_f^0 + 3*N - 3$ ) due to the unit transformation, where  $K_f^0$  was the published data with unit of ( $\mu\text{g kg}^{-1}$ ) ( $\text{L } \mu\text{g}^{-1}$ )<sup>N</sup> in the article.

<sup>g</sup>: Unit transformation: The  $\log K_f'$  was obtained from the equation ( $\log K_f' = \log K_f^0 + 3*N$ ) due to the unit transformation, where  $K_f^0$  was the published data with unit of ( $\mu\text{g g}^{-1}$ ) ( $\text{L } \mu\text{g}^{-1}$ )<sup>N</sup> in the article.

**Table S-4** The fitted results between H/C ratio and the sorption parameters for naphthalene (NAP) and phenanthrene (PHE) to diverse biochars. Please refer to Tables S-2 and S-3 for specific data, and refer to Figure 3 for the linear fitted figure.

parameters	NAP	PHE
$N$	$N = 0.5551 \times \frac{H}{C} + 0.1329, (R^2=0.8083)$	$N = 0.3459 \times \frac{H}{C} + 0.3401, (R^2=0.4727)$
$\log K_f$	$\log K_f = -1.7363 \times \frac{H}{C} + 5.0205, (R^2=0.7631)$	$\log K_f = -0.8900 \times \frac{H}{C} + 4.8089, (R^2=0.2734)$
$\log Q_e (C_e=0.01C_s)$	$\log Q_e = -2.0110 \times \frac{H}{C} + 4.9548, (R^2=0.8020)$	$\log Q_e = -1.5609 \times \frac{H}{C} + 4.1494, (R^2=0.5139)$
$\log Q_e (C_e=0.1C_s)$	$\log Q_e = -1.4559 \times \frac{H}{C} + 5.0876, (R^2=0.6904)$	$\log Q_e = -1.2149 \times \frac{H}{C} + 4.4895, (R^2=0.4166)$
$\log Q_A$	$\log Q_A = -1.8664 \times \frac{H}{C} + 5.503, (R^2=0.8225)$	$\log Q_A = -1.7173 \times \frac{H}{C} + 4.9249, (R^2=0.5389)$

**Table S-5** The sorption parameters of naphthalene and phenanthrene onto other carbon materials (not biochar).

sorbates	samples	C (wt.%)	H (wt.%)	O (wt.%)	N (wt.%)	ash (wt.%)	H/C	N	$\log K_f$ <sup>a</sup>	$\log Q_A$ (exp) <sup>b</sup>	$\log Q_A$ (pre) <sup>c</sup>
naphthalene	humic acid <sup>36</sup>	53.7	4.73	38.8	2.31	0.49	1.057	0.953	2.350	2.346	3.530
		52.2	4.14	40.2	2.85	0.26	0.952	0.969	2.367	2.174	3.727
		50.3	4.38	41.3	2.99	0.36	1.045	0.969	2.382	2.189	3.553
		54.3	3.59	38.3	2.88	0.51	0.793	0.916	2.345	2.563	4.022
		56.8	3.04	36.2	3.51	0.63	0.642	0.893	2.339	2.636	4.304
		56.5	2.98	35.6	3.47	1.84	0.633	0.87	2.354	2.706	4.322
	carbon nanotubes <sup>37</sup>	99.8	1.04	0.1	0	1.42	0.125	0.443	3.750	4.132	5.270
		85.7	0.37	12.1	0.2	1.62	0.052	0.456	3.701	4.092	5.406
		91.9	0.82	5.4	0.45	1.39	0.107	0.572	3.557	4.010	5.303
		84.3	1.32	10.1	2.42	1.89	0.188	0.489	3.219	3.630	5.152
	graphene <sup>38</sup>	76.2	1.03	17.6	5.17	0	0.162			5.106	5.200
	graphene oxide <sup>38</sup>	46.2	2.46	50.9	0.481	0	0.639			3.418	4.310
phenanthrene	humic acid <sup>36</sup>	53.7	4.73	38.8	2.31	0.49	1.057	0.923	3.802	2.629	3.110
		52.2	4.14	40.2	2.85	0.26	0.952	0.932	3.840	2.604	3.291
		50.3	4.38	41.3	2.99	0.36	1.045	0.926	3.818	2.624	3.130
		54.3	3.59	38.3	2.88	0.51	0.793	0.881	3.845	2.883	3.562
		56.8	3.04	36.2	3.51	0.63	0.642	0.868	4.009	3.096	3.822
		56.5	2.98	35.6	3.47	1.84	0.633	0.861	4.015	3.126	3.838
	carbon nanotubes <sup>37</sup>	99.8	1.04	0.1	0	1.42	0.125	0.254	4.394	4.264	4.710
		85.7	0.37	12.1	0.2	1.62	0.052	0.263	4.349	4.214	4.836
		91.9	0.82	5.4	0.45	1.39	0.107	0.263	4.289	4.154	4.741
		84.3	1.32	10.1	2.42	1.89	0.188	0.587	4.248	3.855	4.602
	graphene <sup>38</sup>	76.2	1.03	17.6	5.17	0	0.162			5.135	4.646
	graphene oxide <sup>38</sup>	46.2	2.46	50.9	0.481	0	0.639			3.771	3.828
	sediment <sup>39</sup>	29.1	2.68	7.95	0.93	59.34	1.105	0.643	4.300 <sup>d</sup>	3.842	3.027

	24.2	2.07	5.67	0.6	67.46	1.026	0.561	4.330 <sup>d</sup>	3.965	3.162
	23.4	1.41	5.46	0.54	69.19	0.723	0.521	4.349 <sup>d</sup>	4.022	3.683
	20.6	1.13	4.58	0.43	73.26	0.658	0.489	4.427 <sup>d</sup>	4.129	3.794
	17	0.83	3.42	0.27	78.48	0.586	0.46	4.700 <sup>d</sup>	4.426	3.919
	12.2	0.54	2.14	0.13	84.99	0.531	0.444	4.918 <sup>d</sup>	4.658	4.013
	8.97	0.34	1.36	0.1	89.23	0.455	0.387	5.034 <sup>d</sup>	4.817	4.144
humic acid <sup>40</sup>	51.9	4.9	39.4	3.8	0.1	1.133	0.8	3.445 <sup>e</sup>	2.725	2.979
	54.7	4.9	37.5	2.9	0.1	1.075	0.81	3.530 <sup>e</sup>	2.786	3.079
	53.9	5	38.3	2.7	0.1	1.113	0.81	3.463 <sup>e</sup>	2.720	3.013
	48.4	4.7	46.3	0.6	0.1	1.165	0.82	3.539 <sup>e</sup>	2.770	2.924
lignite <sup>41</sup>	60.4	4.76	23	0	2.58	0.946	0.651	4.570	4.102	3.301
	62.3	4.85	22.7	2.12	2.74	0.934	0.637	4.715	4.264	3.321
	64.3	4.71	20.9	2.05	2.86	0.879	0.629	4.796	4.355	3.415
	65.4	5.5	19.6	1.09	3.04	1.009	0.576	4.931	4.550	3.192
	69.9	5.53	16.3	2.47	3.51	0.949	0.493	4.730	4.428	3.295
	75	4.64	13.3	2.72	3.86	0.742	0.391	4.030	3.810	3.650
	77.9	4.46	10.1	2.7	4.21	0.687	0.304	3.567	3.406	3.745
	80.9	3.67	7	2.66	4.54	0.544	0.24	3.504	3.382	3.990
coal <sup>42</sup>	33.53	4.25	23.63	0.87	37.72	1.521	0.81	4.266	3.522	2.313
	53.94	4.52	26.3	0.76	14.48	1.006	0.71	4.308	3.756	3.198
	32.35	3.2	11.75	0.59	52.11	1.187	0.65	4.430	3.963	2.886
	34.86	2.43	7.74	0.5	54.47	0.836	0.85	5.462	4.609	3.488
	60.45	4.39	15.59	1.09	18.48	0.871	0.72	4.299	3.731	3.428
	65.54	4.48	19.07	0.73	10.18	0.820	0.71	4.387	3.835	3.516
	74.99	4.92	9.86	1.36	8.87	0.787	0.9	4.460	3.415	3.573
	77	4.66	6	1.36	10.98	0.726	0.81	4.511	3.767	3.678
	77.8	4.36	4.82	1.54	11.48	0.672	0.62	4.703	4.273	3.770
	80.13	4	4.21	1.07	10.59	0.599	0.88	5.489	4.531	3.896
	87.31	3.82	4	0.58	4.29	0.525	1.43	5.969 <sup>f</sup>		4.023

humic acid <sup>43</sup>	47.9			1.180	0.819	3.437 <sup>f</sup>	2.671	2.898
	43.7			1.310	0.881	3.353 <sup>f</sup>	2.392	2.675
	47.5			1.240	0.902	3.263 <sup>f</sup>	2.208	2.795
	50.2			1.380	0.735	3.676 <sup>f</sup>	3.083	2.555
	51.8			1.070	0.941	3.237 <sup>f</sup>	1.928	3.087
	53.8			0.920	0.98	3.031 <sup>f</sup>		3.345
	humic acid <sup>44</sup>	53.1	4.5	2.8	1.017	0.902	3.650 <sup>d</sup>	3.919
		54.8	5.3	2.7	1.161	0.923	3.868 <sup>d</sup>	2.694
		55.7	5.7	2.2	1.228	0.958	3.947 <sup>d</sup>	2.453
		57.7	6.2	2.3	1.289	0.961	4.040 <sup>d</sup>	2.503
		59.5	7.3	1.4	60.1	1.472	0.88	4.155 <sup>d</sup>
		60.2	8	1.8	90.2	1.595	0.895	4.541 <sup>d</sup>
condensed organic matter <sup>45</sup>					0.810	0.716	4.088 <sup>g</sup>	3.527
					0.940	0.751	4.163 <sup>g</sup>	3.543
					0.940	0.716	3.998 <sup>g</sup>	3.437
					0.910	0.723	3.509 <sup>g</sup>	2.937
					0.920	0.708	4.164 <sup>g</sup>	3.616
					0.940	0.718	4.294 <sup>g</sup>	3.730
					0.580	0.652	4.056 <sup>g</sup>	3.586
					0.850	0.707	4.221 <sup>g</sup>	3.674
					0.560	0.704	4.042 <sup>g</sup>	4.522
								3.963

<sup>a</sup>: ash corrected. The values of  $\log K_f$  are all ash corrected. The equation that is used for ash correcting is written as  $\log K_f = \log K_f' - \log (1-\eta)$ , where  $K_f'$  was the published data after unit transformation and  $\eta$  was the ash content (wt.%) in biochars.  $K_f, K_f': (\text{mg kg}^{-1}) (\text{L mg}^{-1})^N$

<sup>b</sup>:  $\log Q_A(\text{exp})$  represented the experimental logarithmic maximum adsorption capacity generated from the high-concentration linear fitting of two points in the Freundlich equation at 3/4  $C_s$  and  $C_s$  equilibrium concentration.  $C_s$  refers to the solubility of naphthalene and phenanthrene in water which were 32 mg L<sup>-1</sup> and 1.15 mg L<sup>-1</sup> according to reference<sup>10,24</sup>, repectively.

<sup>c</sup>:  $\log Q_A(\text{pre})$  represented the logarithmic maximum adsorption capacity predicted predicted from the fitted linear relationship between H/C and  $\log Q_A$ .

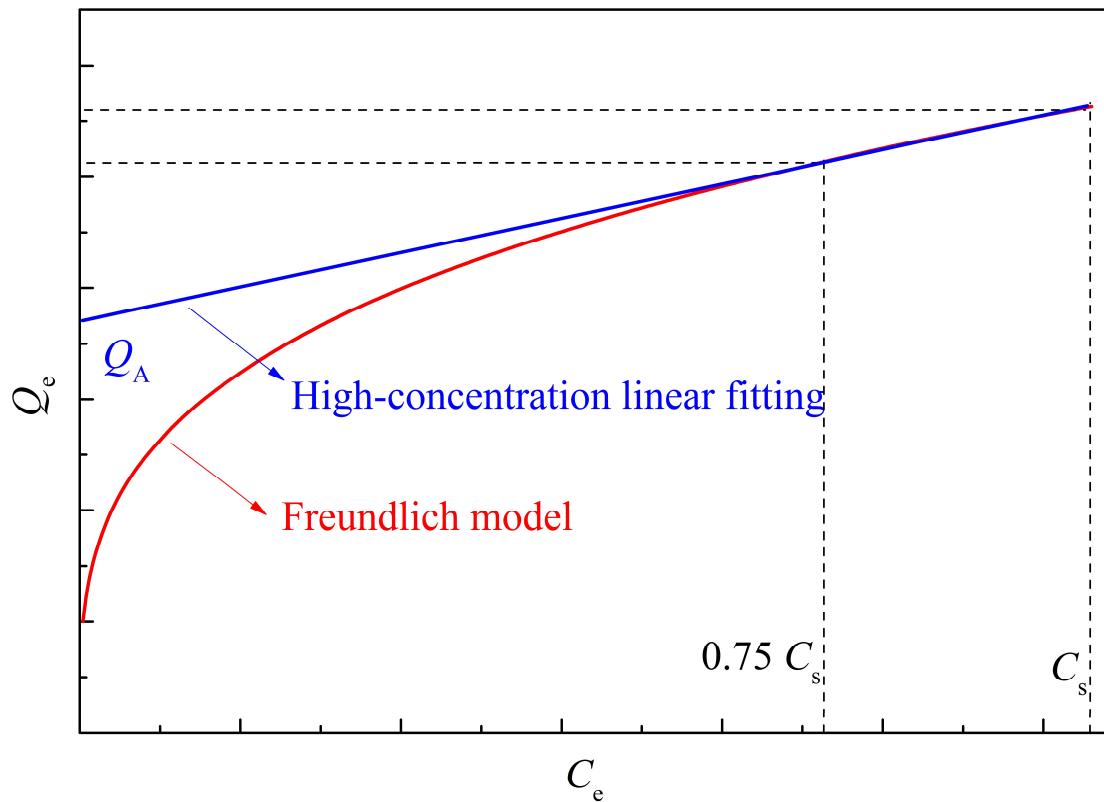
<sup>d</sup>: Unit transformation: The  $\log K_f'$  was obtained from the equation ( $\log K_f' = \log (K_{\text{foc}} * C\%)$ ), where  $K_{\text{foc}}$  was the organic carbon-normalized sorption capacity coefficient with unit of ( $\mu\text{g g}^{-1} \text{OC}$ ) ( $\text{L mg}^{-1})^N$  in the published article.

<sup>e</sup>: Unit transformation: The  $\log K_f'$  was obtained from the equation ( $\log K_f' = \log K_{\text{foc}} - 3 + \log (C\%) - N * \log (5.97)$ ), where  $K_{\text{foc}}$  was the organic carbon-normalized

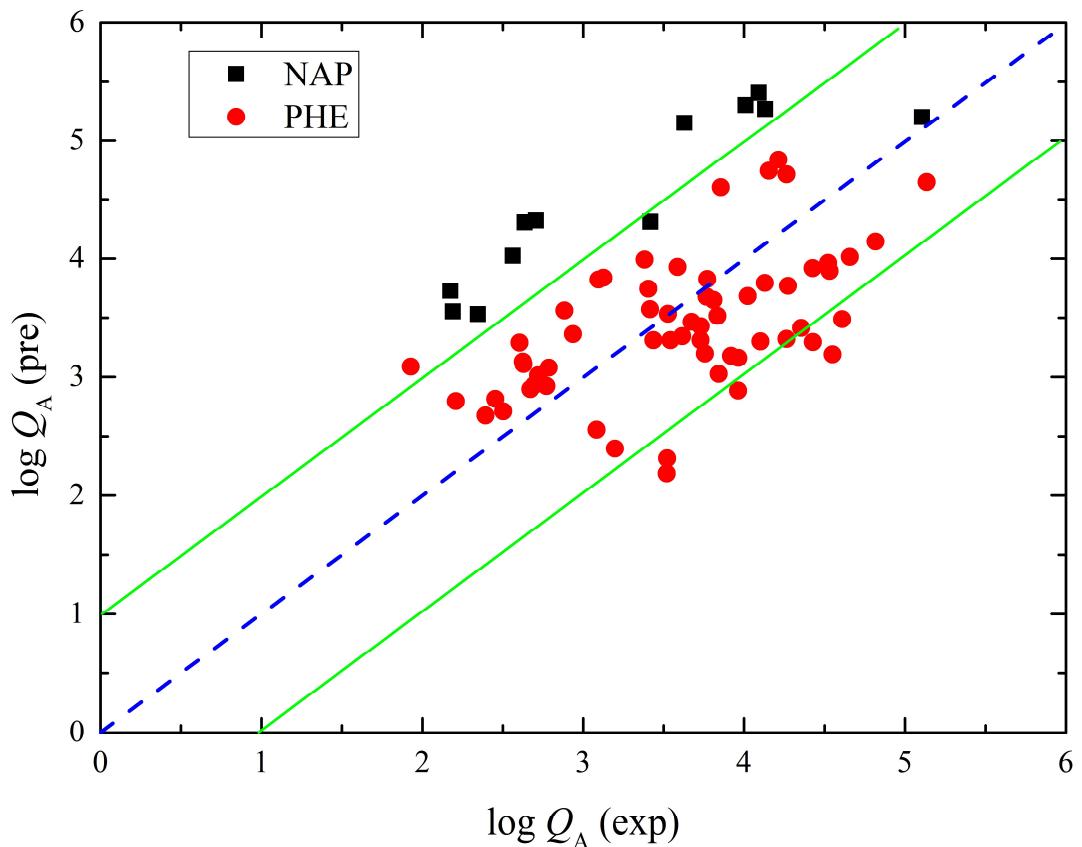
sorption capacity coefficient with unit of ( $\mu\text{g kg}^{-1}$  OC) in the published article.

f: Unit transformation: The  $\log K_f'$  was obtained from the equation ( $\log K_f' = \log K_{\text{foc}} + \log (C\%) + 3*N$ ), where  $K_{\text{foc}}$  was the organic carbon-normalized sorption capacity coefficient with unit of ( $\mu\text{g g}^{-1}$  OC) ( $\text{L } \mu\text{g}^{-1}$ )<sup>N</sup> in the published article.

g: Unit transformation: The  $\log K_f'$  was obtained from the equation ( $\log K_f' = \log K_f + 3*N$ ), where  $K_f$  was the sorption capacity coefficient with unit of ( $\mu\text{g g}^{-1}$ ) ( $\text{L } \mu\text{g}^{-1}$ )<sup>N</sup> in the published article..



**Figure S-1** Illustration of the approximate calculation process of the maximum adsorption capacity from Freundlich parameters using the high-concentration linear fitting method. Two points were used for the high-concentration linear fitting from the Freundlich isotherm at  $0.75C_s$  and  $C_s$ .  $Q_A$  represented the maximum adsorption capacity.  $Q_A = K_f * C_s^N - 4 * (K_f * C_s^N - K_f * (0.75 C_s)^N)$ ,  $C_s$  represented the sorbate solubility in water.



**Figure S-2** Relationships of  $\log Q_A (\text{exp})$  and  $\log Q_A (\text{pre})$  of organic pollutions onto other carbon materials (not biochars).  $\log Q_A (\text{exp})$  represented the experimental logarithmic maximum adsorption capacity generated from the high-concentration linear fitting.  $\log Q_A (\text{pre})$  represented the logarithmic maximum adsorption capacity predicted from the fitted linear relationship between H/C and  $\log Q_A$ . The units of  $Q_A$  are  $\text{mg kg}^{-1}$ . Please refer to Table S-5 for specific data.

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